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Overview of the U.S. Environmental Protection Agency's Storm and Combined Sewer Program Collection System Research

(U.S.) Municipal Environmental Research Lab.
Edison, NJ

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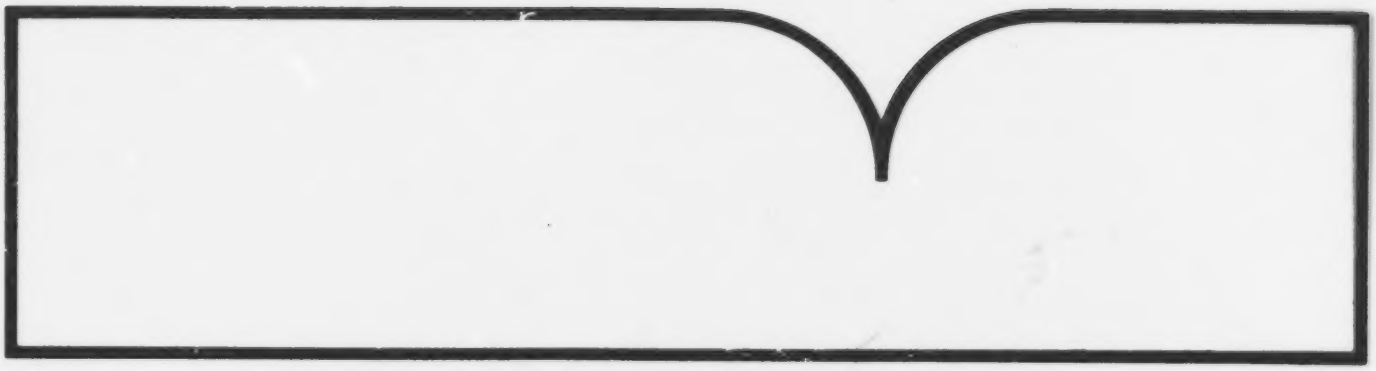

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16. ABSTRACT

A state-of-the-art and assessment of the USEPA's Storm and Combined Sewer Program collection system research pertaining to management alternatives for wet- and dry-weather wastewater transport and interception is presented. These include: maintenance; catchbasins; new sewer design; sewer flushing; polymer injection; infiltration/inflow controls including inflow reduction, Insituform, impregnated concrete pipe and trenchless sewer; upstream storage/attenuation; flow routing and in-pipe storage; new types of flow regulators including swirl and helical bend regulator concentrators, fluidic regulator and Hydrobrake; and a new rubber "duck-bill" tide gate. The emphasis is on optimal use of the existing sewerage system and optimal city-wide cost-effective strategy for the dual purpose of combined sewer drainage and overflow pollution control.

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AN OVERVIEW OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S STORM AND COMBINED SEWER PROGRAM COLLECTION SYSTEM RESEARCH

RICHARD FIELD

U.S. Environmental Protection Agency, Storm and Combined Sewer Section, Wastewater Research Division, Municipal Environmental Research Laboratory (Cincinnati), Edison, NJ 08837, U.S.A.

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Abstract—A state-of-the-art and assessment of the USEPA'S Storm and Combined Sewer Program collection system research pertaining to management alternatives for wet- and dry-weather wastewater transport and interception is presented. These include: maintenance; catchbasins; new sewer design; sewer flushing; polymer injection; infiltration/inflow controls including inflow reduction, Insituform, impregnated concrete pipe and trenchless sewer; upstream storage/attenuation; flow routing and in-pipe storage; new types of flow regulators including swirl and helical bend regulator/concentrators, fluidic regulator and Hydrobrake; and a new rubber "duck-bill" tide gate. The emphasis is on optimal use of the existing sewerage system and optimal city-wide cost-effective strategy for the dual purpose of combined sewer drainage and overflow pollution control.

INTRODUCTION

The USEPA Municipal Environmental Research Laboratory's Storm and Combined Sewer (SCS) Program has been in existence more than 15 yr. This paper describes some of the topics that the SCS Program has been involved with that relate to collection systems. It will give further insight into the management of collection systems for the dual purposes of drainage and pollution control. Maintenance and management of collection systems are necessary for an optimal city-wide cost-effective strategy towards combined sewer overflow pollution control.

It was originally believed that the best answer to abatement of the combined sewer overflow (CSO) pollution problem was the elimination of combined sewers by constructing separate storm and sanitary sewers. More recently, in light of the costs and disruption involved in separating combined sewers, emphasis is being placed on alternatives to sewer separation. Sewer separation would cost in the order of $100 billion or 3 times the cost of the alternative control measures (Heaney *et al.*, 1977).

It is further emphasized that urban stormwater runoff itself can be a significant source of stream pollution. Sewer separation would not cope with this pollutional load.

MAINTENANCE

Improved sewerage system inspection and maintenance is absolutely necessary for a total system approach to municipal water pollution control. One cannot afford the upgrading and proper operation of sewage treatment plants while a significant amount of sewage leaks into streams at the upstream points in the sewer network. Premature overflows and backwater intrusions during dry- as well as wet-weather caused by malfunctioning regulators and tide gates, improper diversion settings, and partially filled interceptors and sewers can thus be alleviated. The resulting abatement obtained must be viewed as an ancillary benefit of required system maintenance. Regulatory agencies should be anxious to strive for policy to enforce collection system maintenance.

CATCHBASINS

Historically, the role of catchbasins has been to minimize sewer clogging by trapping coarse debris and to reduce odor emanations from low-velocity sewers by providing a water seal. A few years ago a project was undertaken to assess the value of catchbasins as they are presently designed and maintained (Lager *et al.*, 1977). Optimized basin configuration, design and maintenance for removing solids before sewerage system entry was also investigated. Evaluations showed that a catchbasin contains the equivalent of one person's daily contribution. Consequently, the utilization of catchbasins (which depends on a city's network configuration and multi-agency desires) can either contribute to the pollutional load or aid in reducing downstream treatment depending on their design and maintenance. A full-scale demonstration of catchbasin technology was recommended.

In a project conducted in the West Roxbury section of Boston, 3 catchbasins were cleaned and subsequently monitored during 7 runoff events (Aronson *et*

al., 1981). Catchbasins were shown to be potentially quite effective for solids reduction (60–97%). Catchbasin removals of associated pollutants such as chemical oxygen demand (COD) and biochemical oxygen demand (BOD) were also significant (10–56 and 54–88%, respectively). To maintain the effectiveness of catchbasins for pollutant removal will require more frequent cleaning than is usually carried out—probably twice a year depending upon conditions. The increased cost of cleaning must be considered in assessing the practicality of catchbasins for pollution control. A cost effectiveness analysis is being initiated which will utilize the actual field data acquired in West Roxbury.

NEW SEWER DESIGN

Traditional sewer design is based on the precepts that:

(1) Storm generated flows do not contain pollutants;

(2) Self-cleansing velocities are obtained during storms; and

(3) Old economic principles which only considered the costs for conventional flood control and drainage prevail.

Consequently, the sewers were designed for high flow conditions. But how often does maximum flow occur? Once in 5 yr? Once in 10 yr? Once in 25 yr? Therefore, dry-weather loads deposit.

Solids deposition in sewer lines has always been a plague to effective maintenance. Recently, the significance of such loads as a major contribution to first flush pollution has been recognized.

New design concepts are needed which take into account pollution abatement. The costs of designing sewers for both flood control and pollution abatement are justified under new economic principles which evaluate alternatives such as steeper sewers with more pumping and special cross-sectional shapes both to obtain minimum solids carrying velocity at low dry-weather flows in order to avoid deposition vs the cost for control of the added first flush from old design concepts which allow dry weather deposition. A project was undertaken to study new sewer designs based upon maintaining adequate low flow solids carrying velocity to alleviate sewer sedimentation and resultant first flush pollution and premature bypassing during storms (Sonnen, 1977). The study concluded that feasible methods of controlling first-flush pollution in new designs exist. They include increasing conduit slopes and providing cunette sections or other pipe shapes that maintain high velocity during low flow periods. These alternatives are directed toward minimizing accumulation of solids in pipelines to minimize downstream treatment in a systemized optimization manner.

In a project conducted in Elizabeth, NJ, alternatives for pollution abatement from CSO were evaluated (Kaufman & Lai, 1978). The following types of system designs were compared: separate storm and sanitary, conventional combined, and advanced combined with varying amounts of in-pipe and/or satellite storage and controlled flow routing. Basically, the new method is the old combined sewer concept which incorporates in-sewer storage for wet-weather flow. The cost-effectiveness comparison was based on achieving a desired effluent quality assuming a new sewer system.

The study found that providing additional storage in a new combined sewer system should result in the least-cost system for pollution control. This storage can be provided by enlarging the size of the upstream sewer reaches, if site restrictions result in costly satellite storage basins. The study also recommended that combined sewers should be considered for new development in urban areas with relatively high imperviousness and that these sewers should be designed to maintain flushing velocity for dry weather flows. Also, upstream storage in the collection system (either in-pipe or satellite) should be required in new combined systems and, where practical, for the improvement of existing systems.

SEWER FLUSHING

Sewer flushing has been shown to be an effective means for substantially reducing solids deposited during dry weather in small diameter combined sewer laterals (Pisano *et al.*, 1979; Kaufman & Lai, 1980). This alleviates wet-weather CSO pollution and reduces downstream treatment requirements. Roughly 35–45% removal of organics were demonstrated for segment lengths greater than 1000 ft (305 m).

POLYMER INJECTION

Polymer slurry injection into sewage has resulted in significant hydraulic friction reductions (Chandler & Lewis, 1977; Richardson, 1969); hence, a temporary increase (up to 144% reported) in line capacities is achieved. This increase is significant in stormwater applications because the sewer surcharges associated with excess wet-weather flows are generally of short duration; thus, a marginally inadequate line can be bolstered by polymer injections at critical periods. In effect, this increases the overall treatment efficiency by allowing more of the flow to reach the treatment plant, while flooding from sewer surcharges is decreased. Polymer concentrations of between 35 and 100 mg l^{-1} decreased flow resistance sufficiently to eliminate surcharges of more than 6 ft (1.8 m).

INFILTRATION INFLOW CONTROLS

Inflow reduction

The major objective of flow reduction techniques is to maximize the effective collection system and treatment capabilities and prevention of downstream over-

Fig. 1. Insituform liner being inserted into a sewer through a manhole, Northbrook, IL.

flow pollution by reducing extraneous sources of inflow.

The Springfield (IL) Sanitary District has engaged in a concerted program to remove improper connections and extraneous inflows to its sewer system (Peter & Troemper, 1968). The district was able to reduce downspout connections to its sewers substantially. Besides improving the use of the sewerage system, the profound significance was in the elimination of numerous public complaints regarding basement flooding. From a cost standpoint, the district has estimated that the expense of removing the roof leaders will be fully returned within 16 months by virtue of reduced operation and maintenance for the sewerage system.

Infiltration control research needs

Recently it was shown that infiltration control by sewer system rehabilitation is only partially effective because of migrating leakage and the difficulties of correcting house connections. Ways to remedy this are being investigated. First by developing new network evaluation and corrective procedures which will detect the potential for migrating leaks. And second by investigating more feasible ways (other than excavating) to control the house lateral infiltration problem.

Insituform

Insituform, originally developed in Great Britain in the early 1970's, is a relatively new method for sewer rehabilitation in the United States. It is being demonstrated in Northbrook, IL and Hagerstown, MD under the SCS Program (Driver & Olson, 1981; U.S. Environmental Protection Agency, 1979).

The basic objectives of the two projects are to establish the feasibility and cost effectiveness of the Insituform process for rehabilitating sanitary sewers in need of structural rehabilitation and infiltration control. Approximately 8300 ft of sanitary sewers, ranging in size from 8 to 27 in., will be rehabilitated by the Insituform process during the two projects.

The process makes use of a polyester fiber felt tubing (sealed at the downstream end to form an elongated bag), lined on one side with polyurethane and fully impregnated with a liquid thermal-setting resin. This tubing, tailored to the exact diameter and length of pipe to be repaired, is inserted into the line through an existing manhole. Figure 1 shows an Insituform liner being inserted into a sewer through a manhole in Northbrook, IL. Cold water pressure forces the tubing through the pipeline, inverting and pressing the Insituform material firmly against the inner pipe walls. The water is then heated, causing the resin to form a hard, impermeable lining.

Insituform literally creates a new pipe within the damaged original providing its own structural integ-

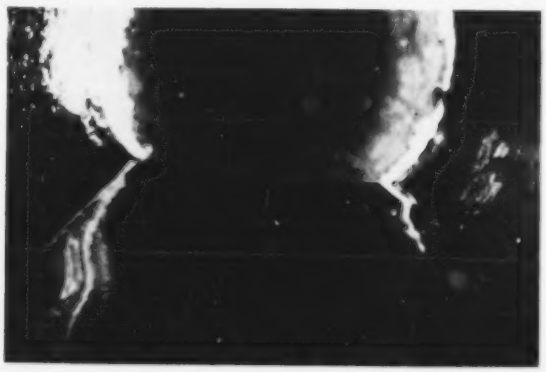

Fig. 2. Insituform liner in a 12-in. sewer.

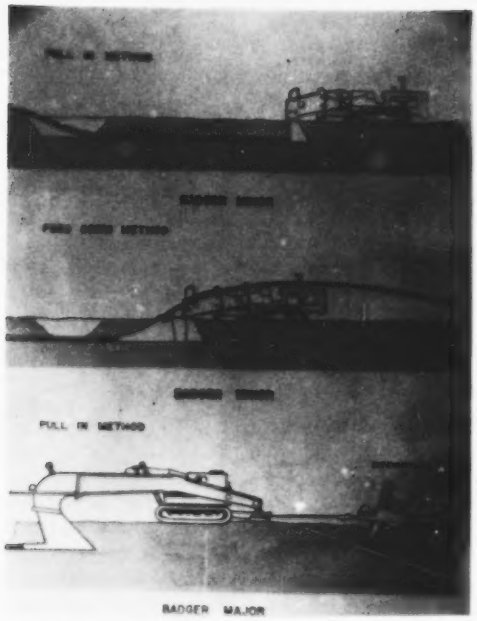

Fig. 3. Two configurations of a shallow trenchless sewer emplacer and one of a deep trenchless emplacer. The shallow emplacer handles pipe up to 457 mm dia and up to 1.8 m deep. The deep emplacer handles pipe from 457 to 686 mm dia and from 1.8 to 3.7 m deep.

rity. Upon insertion, the material is pliable and the resin is a viscous liquid. This allows the Insituform to fill cracks, bridge gaps, surmount rubble and even turn 45° angles.

Figure 2 shows an Insituform liner in a 12 in. sewer. Since it molds itself against the pipe wall and the lining itself is relatively thin, there is virtually no flow-through area reduction. It is claimed that its smooth surface will even improve flow capacity by reducing friction. Its chemical makeup resists corrosion which causes infiltration problems in conventional piping.

The said advantages of insituform over conventional polyethylene sliplining which the projects will attempt to verify are:

1. Insertion through existing manholes rather than entry excavation which (a) reduces installation time and costs; (b) reduces safety risks; (c) reduces construction excavation related environmental damage (e.g. to underground utility lines); (d) reduces traffic upsets; (e) reduces or eliminates easement right-of-way negotiations and costs; (f) maintains structural integrity of original pipes whereas sliplining requires top half of a portion of original pipe to be cut away; (g) enhances public relations.

2. Conforms to inside diameter of original pipe and covers joints which eliminates root intrusion and the need for grouting at these locations and prevents infiltration.

3. Greater flow capacity due to greater post-corrective pipe diameter.

4. Allows for service connection reestablishment by use of a within pipe cutting machine, whereas sliplining requires excavation at each service connection.

Impregnated concrete pipe

Concrete pipe is the most popular and most widely used type of pipe in sewer construction. Research conducted by the SCS Program found that impregnation of the pipe reduced the permeability of the concrete (Ludwig, 1980; Southwest Research Institute, 1971). Thus, corrosive soil chemicals and sulfuric acid produced by septicity were inhibited from reacting with the interior structure of the concrete and steel reinforcing rods. Pipe deterioration leading to infiltration and structural failure is significantly abated by this process.

It was also established that nonreinforced pipe impregnated with sulfur approached the strength of steel reinforced pipe. This dramatic strength improvement, coupled with the improved resistance to corrosion, points to the possibility that sulfur impregnation will be used in future installations at an attractive savings in material cost. It is estimated that such saving will range from $0.83 to $2.08 per linear foot of 27-in dia pipe.

Today it is estimated that by 1990 over 90,000 miles of new sewer pipe will be required in the U.S. The cost? $17 billion (Heaney *et al.*, 1977). However, this figure assumes the use of conventional reinforced concrete pipe. It appears from our work that concrete pipe impregnation could result in a substantial taxpayer savings of half a billion dollars over the next decade.

Fig. 4. Trenchless sewer plowing and installation process, South Bethany Beach, DE.

Fig. 5. Hydrobrake installation, Toronto, Ontario, Canada.

Fig. 6. The Hydrobrake in a vertical position, Cleveland, OH.

Trenchless sewer

Control of infiltration should first take place during sewer pipe installation. Better construction materials and proper installation techniques are necessary. Trenchless sewer construction by plowing has been successfully demonstrated in a project conducted at South Bethany Beach, DE (Beetschen & Henry, 1978). The technique consists of plowing in solvent welded polyvinyl chloride (PVC) pipe on a grade established and controlled by a laser unit. (The installation is similar to the technique of plowing in underground cables.) This resulted in a system with virtually little, if any, infiltration due to the superior corrosion resistance of the PVC pipe used and, since plowing in is done in 600 ft lengths, there are far fewer joints than conventional pipe and these joints are chemically welded, which also leads to less infiltration than conventional pipe. In the most conservative form of cost comparison, the trenchless method was 16% less expensive. Figure 3 shows a drawing of the installation and Fig. 4 shows a photograph of the plowing in process.

Table 1. Cost comparison between surface ponding techniques and conventional sewer installation (Field *et al.*, 1977)

Site	Description	Cost estimate ($)	
		With surface ponding	With conventional sewers
Earth City, MI	A planned community including permanent recreational lakes with additional capacity for storm flow	2,000,000	5,000,000
Consolidated Freightways, St Louis, MI.	A trucking terminal using its parking lots to detain storm flows	115,000	150,000
Ft Campbell, KY	A military installation using ponds to decrease the required drainage pipe sizes	2,000,000	3,370,000
Indian Lakes Estates, Bloomington, IL	A residential development using ponds and an existing small diameter drain	200,000	600,000

Fig. 7. Stormwater routing control center, Detroit, MI.

UPSTREAM STORAGE ATTENUATION

Surface ponding is the most common form of detention used by developers. Apparent economic benefits of surface ponding for flood protection are derived from the savings over a conventional sewer project. Several surface ponding sites are listed in Table 1. Table 1 illustrates the economic benefit of drainage systems which utilize surface ponding. It is important to note that pollution and erosion control benefits of the basins are not included in this comparison.

The utilization of depression storage by flooding curblines, right-of-ways and lawn areas for brief periods reduces downstream flooding which usually has more of a negative impact than upstream flooding and also reduces the need for larger pipes.

A project in Cleveland, OH is demonstrating how controlling the rate of stormwater, stored upstream, entering the sewerage system alleviates basement flooding and overflow pollution (Theil & Candaras, 1981). The flowrate will be regulated by a Hydrobrake internal energy dissipator. This small device which is located at the downstream end of an underground stormwater tank will deliver virtually a constant discharge rate regardless of head variations. This is accomplished without the need of moving parts or external energy sources. Figure 5 shows the installation of a Hydrobrake and Fig. 6 shows a Hydrobrake with another configuration.

FLOW ROUTING AND IN-PIPE STORAGE

Another collection system control method is in-sewer or in-pipe storage and routing of storm flows to make maximum use of existing interceptors and sewer

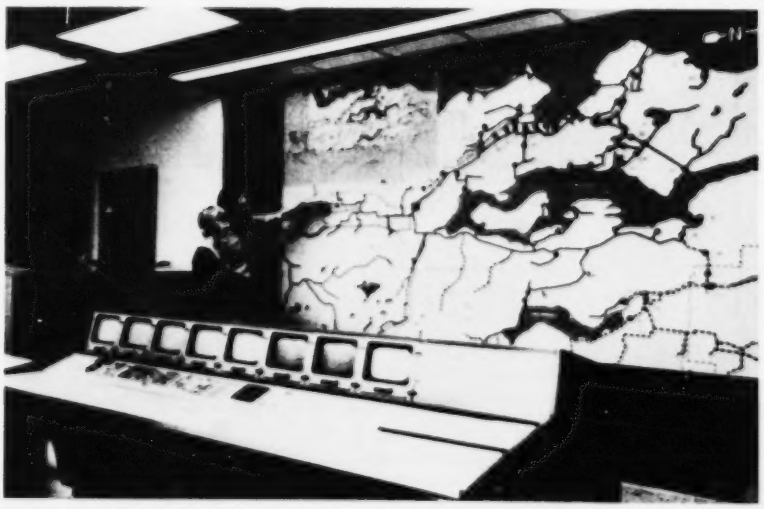

Fig. 8. Another stormwater routing control center, Seattle, WA.

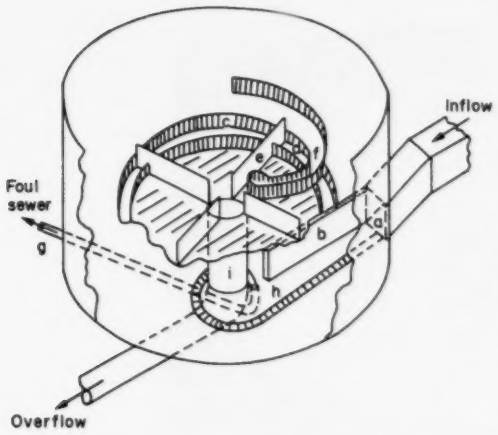

Fig. 9. Isometric view of swirl regulator/concentrator. a—inlet ramp; b—flow deflector; c—scum ring; d—overflow weir and weir plate; e—spoilers; f—floatables trap; g—foul sewer outlet; h—floor gutters; i—downshaft.

line capacity to minimize overflows and maximize system treatment. The general approach comprises remote monitoring of rainfall, flow levels, and sometimes quality, at selected locations in the network, together with a centrally computerized console for positive regulation. This concept has proved to be effective in Detroit (Watt *et al.*, 1975) and Seattle (Leiser, 1974). Figures 7 and 8 show Detroit's and Seattle's routing control centers, respectively.

Case study—Seattle, WA

The Seattle in-sewer storage system covering 13,250 acres costs $5.3M or $400 per acre as opposed to tens of thousands of dollars per acre for other alternatives (Field *et al.*, 1977; Leiser, 1974). A specific Seattle study revealed that sewer separation would cost $10,000 per acre. The low cost for in-pipe storage is attributed to a quasi-structural system which takes advantage of the existing combined sewer network; and control gates installed at strategic points only. The system is highly signal and computer-oriented with minimal hardware requirements. In fact, one-half the costs were for computers and related software. Of course, in-sewer storage is site specific since implementation of the concept requires a relatively large and flat existing combined system.

Overflow and pollutant reduction from 12 major overflow points averaged 55 and 68%, respectively. Also, 90% of the overflow volume was reduced by experimental automatic control. Effectiveness of the system is proven by a 1–2 mg l^{-1} DO increase and a 50% coliform reduction in the receiving water.

In-stream/sewer storage for stormwater

If stormwater pollution/attenuation is required, in-stream and in-sewer storage can also be used for stormwater during an event with subsequent discharge to treatment following the storm.

NEW TYPES OF FLOW REGULATORS

The use of regulators and their maintenance was mentioned above. There are roughly 18,000 CSO points or regulators in this country. New types of regulators have been developed by the SCS Program for more effective overflow control.

Swirl and helical bend regulator/concentrators

Quantitative and qualitative control, or the "2-Q" aspect of overflow control recognizes regulators' responsibility of controlling both quantity and quality of overflow to receiving waters. Both the dual functioning swirl and helical bend regulator/concentrators have shown outstanding potential for providing "2-Q" control for the first time in this country.

The major objectives of swirl and helical devices are to regulate both the quantity and quality of storm flow at the point of overflow. Solids separation is caused by the inertia differential which results from a

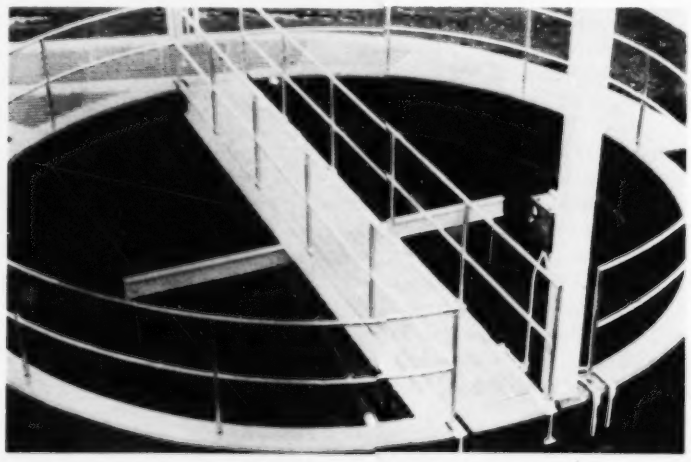

Fig. 10. Plan view of swirl regulator/concentrator, Lancaster, PA.

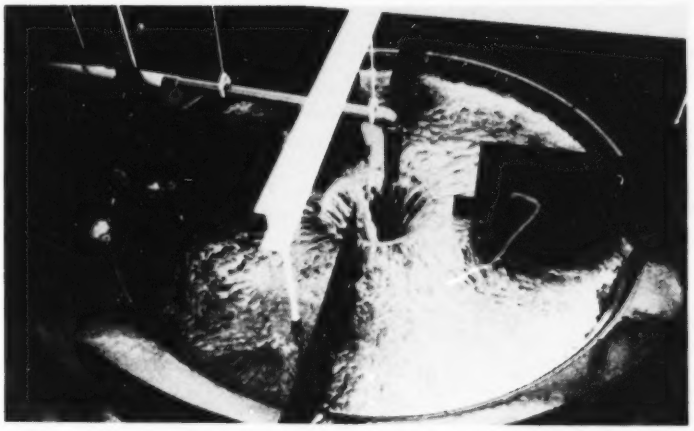

Fig. 11. Swirl regulator/concentrator in wet-weather operation, Lancaster, PA.

circular or secondary path of travel. The flow is separated into a large volume of clear overflow and a concentrated low volume of waste that is intercepted for treatment at the wastewater treatment plant. Again, it is emphasized that in addition to regulation of combined sewer flow, these devices provide high-rate preliminary treatment for heavy solids removal. Figure 9 shows an isometric of the swirl. Major attributes of the swirl concentrator are relatively constant treatment efficiency over a wide range of flowrates, its simple annular shaped construction, and the absence of mechanical parts which use energy. Swirl and helical bend regulator/concentrators have been modeled and, in several cases, demonstrated (Field, 1973, 1974; Sullivan, 1972; Sullivan *et al.*, 1974, 1975; Field & Traver, 1979). Figure 10 shows a plan view of a Program demonstration in Lancaster, Pennsylvania (U.S. Environmental Protection Agency, 1971; Pisano *et al.*, 1981). Figure 11 shows the Lancaster swirl in wet-weather operation and Fig. 12 shows a sample of some wet-weather grit from the Lancaster swirl degritter which degrits the foul concentrate underflow from the main swirl regulator. As shown in Table 2, the swirl regulator/concentrator achieves an average SS mass loading net removal benefit of 19% over conventional regulators (Drehwing *et al.*, 1979; Field & Masters, 1977).

Again, if there is a concern for separate stormwater pollution, swirls and helicals similar to the combined sewer overflow regulator variety can be installed on separate storm drains before discharge and the resultant concentrate can be stored in relatively small tanks since concentrate flow is only a few percent of total flow. Stored concentrate can later be directed to the sanitary sewer for subsequent treatment during low-flow or dry-weather periods, or if capacity is available in the sanitary system, the concentrate may be diverted to it without storage. This method of stormwater control would be cheaper in many instances than building huge holding reservoirs and it offers a feasible approach to the treatment of separately sewered urban stormwater. The aforementioned Boston installation employs this concept (Pisano *et al.*, 1981; U.S. Environmental Protection Agency, 1978).

Fluidic regulator

The fluidic regulator concept offers most of the flexibility and performance of the dynamic regulator, yet retains the low cost, simplicity, reliability of operation and ease of maintenance of the static regulator. The fluidic regulator consists of a structure with no mechanical moving parts in the sewage flow stream and

Fig. 12. Sample of wet-weather grit from swirl degritter, Lancaster, PA.

Table 2. Swirl regulator/concentrator vs conventional regulator (Drehwing *et al.*, 1979; Field & Masters, 1977)

	Swirl regulator/concentrator						Conventional regulator			
	Average SS per storm (mg l^{-1})			Mass loading (kg)			Mass loading (kg)			
Storm No.	Inf.	Eff.	(%) Rem.*	Inf.	Eff.	(%) Rem.*	Inf.	Underflow	(%) Rem.†	Swirl net removal benefit (%)‡
2–1974	535	345	36	374	179	52	374	101	27	25
3–1974	182	141	23	69	34	51	69	33	48	3
7–1974	110	90	18	93	61	34	93	20	22	12
10–1974	230	164	29	256	134	48	256	49	19	29
14–1974	159	123	23	99	57	42	99	26	26	16
1–1975	374	167	55	103	24	77	103	66	64	13
2–1975	342	202	41	463	167	64	463	170	37	27
6–1975	342	259	24	112	62	45	112	31	28	17
12–1975	291	232	20	250	168	33	250	48	19	14
14–1975	121	81	33	83	48	42	83	14	17	25
15–1975	115	55	52	117	21	82	117	72	62	20

*Data reflecting negative SS removals at tail end of storms not included.

†For the conventional regulator removal calculation, it is assumed that the SS concentration of the foul underflow equals the SS concentration of the inflow.

‡Calculated by subtracting the hypothetical percent SS removals in a conventional regulator, from the percent SS removals in a swirl regulator/concentrator.

permanently open flow passages (Bowles Engineering Corporation, 1969). Figure 15 is an actual photograph of a fluidic sewer regulator before installation at the 67th/Callowhill Streets site in Philadelphia, PA (Freeman, 1977). Figure 16 is an isometric view of the fluidic regulator. The construction is from standard, noncorrosive materials such as concrete and stainless-steel. These characteristics render the fluidic regulator minimally susceptible to common problems such as blockages, corrosion, fouling, jamming, etc., affecting standard moving part regulators and essentially equivalent to standard static regulators.

Another significant advantage of the fluidic regulator is that it is self-powered. Control energy is derived directly from the sewage flow, thus eliminating the requirement of external power.

The cost of refitting a fluidic regulator was estimated to be 40% more and 50% less than retrofitting a conventional static and a conventional dynamic regulator, respectively. The installation of a fluidic regulator in a new location was estimated to cost 10% more than a conventional static unit. It was further estimated that maintenance of the fluidic regulator would be less than conventional dynamic overflow regulators since it is mechanically simpler and its materials are less costly.

The fluidic regulator obtains operational flexibility comparable to that of complex dynamic regulators through the sensing of water levels by simple dip tube sensors, which can be located in the interceptor, or upstream of the regulator in the combined sewer, or both.

Hydrobrake

The Hydrobrake discussed earlier as regulator for stored effluent can also be used as a CSO regulator. This is being demonstrated in Cleveland, OH (Theil & Candaras, 1981) and New York City, NY (U.S.

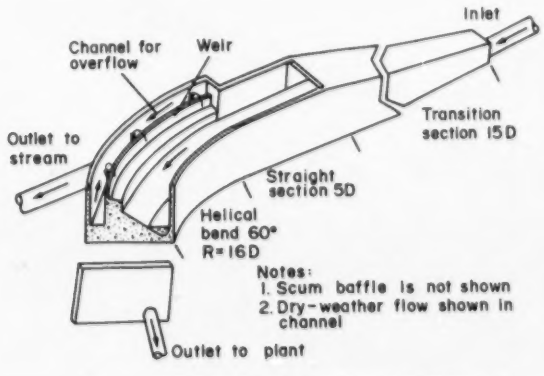

Fig. 13. Isometric view of helical bend regulator.

Fig. 14. Helical bend regulator, West Roxbury, Boston, MA.

Environmental Protection Agency, 1980). The device is static yet has the advantage over conventional static regulators in that it provides a relatively constant Q regardless of head. Figure 17 illustrates this feature. Figure 18 shows an isometric view of the Hydrobrake.

NEW TIDE GATE

Tide gates are employed to protect collector sewers and interceptors from the inflow of tidal or high river-stage waters. Without such control devices, backflows would surcharge collector sewers (causing flood con-

Fig. 15. Fluidic sewer regulator, 67th/Callowhill Sts Site, Philadelphia, PA.

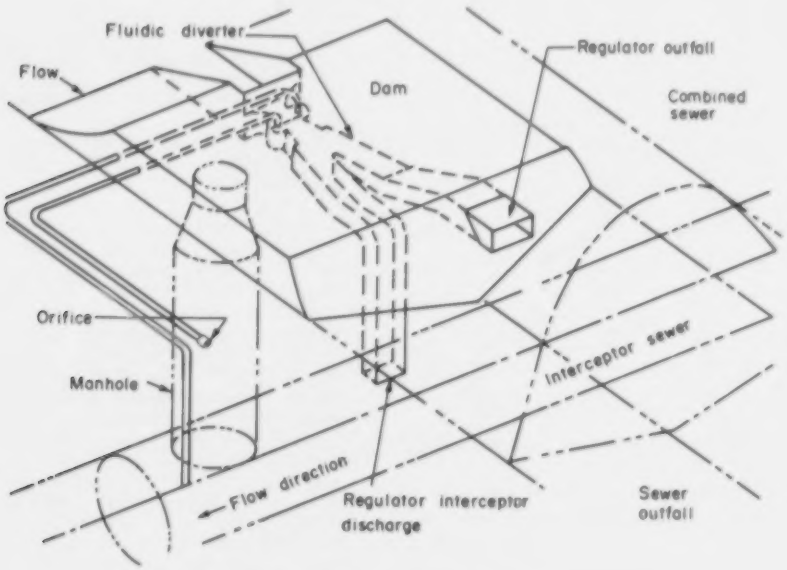

Fig. 16. Isometric view of fluidic regulator.

ditions), interceptors, pumping stations and treatment plants and adversely affect treatment processes and the capacity of the drainage system.

There are severe problems with the types of tide or flood gates currently in use, such as failure to close tight (because of debris blockages, warpage, and corrosion), a tendency to get stuck in one position and the need for constant regular maintenance. Poor tide gate performance results in higher treatment costs, treatment plant upsets, greater pollutional loads due to downstream overflows and plant bypassing and flooding in upland tributary drainage areas. Therefore, one tries to maintain them, but maintenance is expensive and time consuming. There is a genuine need for a new type tide gate which would not be subject to the problems described.

A development and demonstration was initiated with New York City, NY to evaluate a rubber "duckbill" tide gate in a combined sewer outfall (U.S. Environmental Protection Agency, 1980). It is a totally passive device, requiring no outside energy source to operate and apparently would be virtually maintenance free, yet seal tightly around large solid objects. Figure 19 shows an isometric drawing of the device.

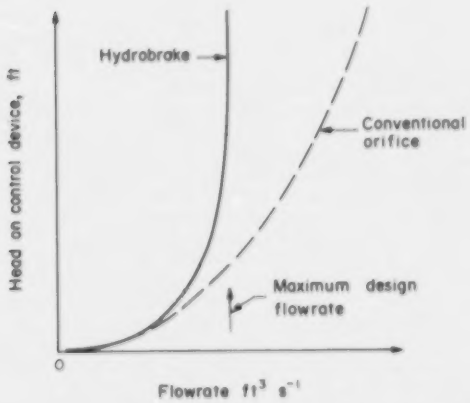

Fig. 17. A graph showing a conceptual comparison of the Hydrobrake and a conventional orifice: the Hydrobrake has a nearly constant head-to-flow rate ratio. (Recent EPA data show that actual performance is slightly less than shown in this diagram, but still much superior to the conventional orifice.)

SUMMARY

In summary, collection system controls include flushing, polymer feed, inflow infiltration control, improved regulator devices and remote monitoring control systems. The emphasis is upon optimal utilization of the existing facilities.

There is tremendous opportunity to effectively utilize the existing collection system as an integral part of

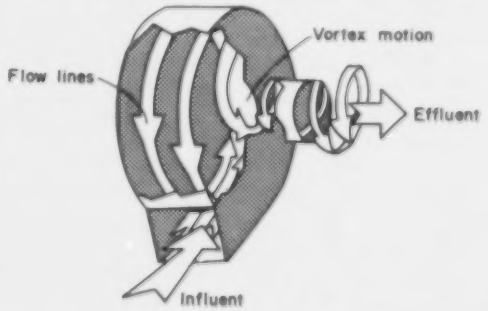

Fig. 18. Isometric view of the Hydrobrake operation showing principal of vortex fluid motion.

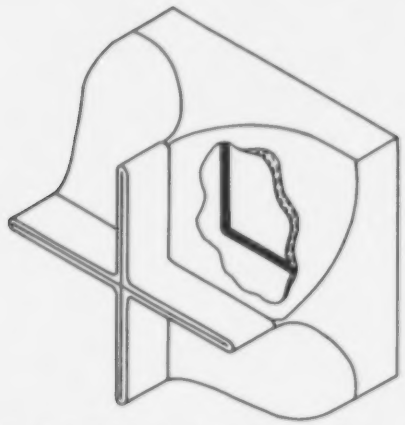

Fig. 19. Isometric view of the rubber "duck bill" tide gate.

the actual treatment system. Therefore, it is recommended that support be gathered to foster this.

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